

HORIZON



Air Crash – The Deadly Puzzle

Text adapted from the programme transmitted
14 February 1994

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Dear Horizon Viewer

Air crash investigations are fascinating. Stevenson crossed with Sayers. Engineering and detective work together. Every TV channel in the world has someone trying to follow the progress of an investigation – and until now they have all failed.

Air crash investigators are engineers first, pundits second. They go looking not for confrontation but for the technological truth – if it can be found. They don't want the camera staring over their shoulder, second-guessing their every move.

The unseen hero of this programme is Marian Marzinsky – the Chicago-based freelance producer who obsessively pursued the filming of an investigation and like everyone else was turned down time and time again, until the Panamanian authorities allowed him to follow theirs. The visible heroes are the investigators themselves, good engineers with a flair for detection, who pursue every lead with enthusiasm, but are prepared to admit they have drawn a blank, and to start again. Filming with them was a true pleasure.

Perhaps the most significant point about this story is that there is no neat ending. In real life there never is, but often we pretend otherwise. In this case there was no 'smoking gun'; there was a cool, painstaking assessment of the likely truth. It was important that the programme showed that; a slice of real life for once on screen.

Peter Ceresole
Producer

NARRATOR (MARK HALLILEY)

The twenty-second of June, 1992, was a stormy day in Panama City – typical conditions for summer in the Gulf of Panama. The storms were affecting airline traffic in the area, but that evening Copa Airlines flight 201 was due to leave on schedule for Cali in Colombia. Copa is Panama's largest airline, flying Boeing 737s.

After take-off, the pilot asked air traffic control for permission to deviate round a storm in the Gulf of Panama. This took the flight over the Darien jungle, one of the most remote areas in Central America. The pilot told the controller that he was turning back onto course and the flight passed out of radar range. It was never heard from again.

AIR TRAFFIC CONTROLLER

After he mentioned that he was going to rejoin the airway and the controller answered him, his request about the weather, maybe two minutes later, if I'm not mistaken, the signal disappeared.

NARRATOR

The search started at dawn. Helicopters and search parties quartered the jungle looking for signs of the crash. The first discovery was a large burnt area in the trees. It looked as though the plane had crashed there. A long technical effort began to solve the mystery of what had downed the aircraft and its 47 passengers and crew.

The crash site was miles from any habitation – Panamanian search parties took a day to reach the wreckage. They found pieces of the aircraft lying on the jungle floor. Very quickly, Indian searchers found the aircraft's cockpit voice recorder, one of the so-called 'black boxes' – it's in an orange case for high visibility. As it was from an aircraft made in the United States, the recorder was flown to Panama City and then to Washington for analysis. It records all cockpit sounds on a continuous loop of tape and is a crucial tool in crash investigations. The Panamanian Director of Civil Aviation, Zosimo Guardia, briefed the press on the finding of the voice recorder.

Boeings are manufactured in the USA and as is customary, Guardia

requested technical assistance from the National Transportation Safety Board, the NTSB.

THOMAS HAUETER (*Chief Investigator, National Transportation Safety Board*)

The crash happened on a Saturday evening. I was called, oh, early Sunday morning. The Panamanian government told us that a 737 had crashed somewhere in the jungle, or possibly in the ocean – they didn't know at that time – and they requested assistance immediately. Through a series of phone calls with the local Federal Aviation Administration, with Boeing, the manufacturer of the aircraft, and with Pratt and Whitney, the manufacturer of the engines, we started putting together a team to go down. We arrived in Panama fairly early on Monday afternoon and were given a briefing by the Panamanians.

NARRATOR

In spite of the NTSB presence, this is a Panamanian investigation. The Panamanian leader is Ernesto Ponce.

ERNESTO PONCE

(*Giving briefing*) . . . and this area is a route for the cocaine people. They use Turbo Commanders, they can fly very high.

NARRATOR

The combined teams have to decide how they'll tackle the technical investigation. Haueter's first step is to take his team to see an intact 737.

THOMAS HAUETER

When we first arrived on scene I took an inventory of the people who were with me: there were several who had never walked around a 737. They had a sister ship, and so we had them open the aeroplane up so everybody could see what the inside of the cargo compartment looks like, what the cabin overhead storage bins look like, their mounting structures, what the cockpit looks like, where the APU mounts – everything you could see about the aeroplane to try and identify parts. We brought along an FAA bomb specialist, Cal Walbert, because of the area – the aeroplane was going

to Latin America, to Cali, Colombia. Unfortunately, the first thing you jump at is the possibility of a bomb and terrorists.

NARRATOR

But they can't make any easy assumptions. The 737 is the most used airliner in the world. Two thousand five hundred have been sold. It's important to find out exactly what went wrong with Copa 201.

THOMAS HAUETER

We have to find out: did this aeroplane crash because of a manufacturing defect – did it crash because there's something designed into the system that pilots don't understand, that needs to be publicised? That seems unlikely in an aircraft that's been in operation as long as the 73, but things happen, you never know what might pop up. There may be something that seemed very reasonable 15–20 years ago that now is not functioning as designed, or is wearing out sooner than predicted – whatever. We have to look into those.

NARRATOR

The investigators set up in a classroom at the Panamanian Aviation School. They studied the maintenance records of the crashed aircraft and the documents relating to the flight.

After studying the paperwork, they're ready to go into the jungle. The team flies for an hour, to the nearest airstrip to the crash site. Exceptionally, they've allowed a camera team to accompany them. Because investigations involve sensitive questions of legal liability, this is the first time a whole investigation has been filmed as it happens.

THOMAS HAUETER

(*At the crash site*) See here, this is the headset for talking to the passengers to give the announcements.

(*Interview*) The Panamanian people who were there the day before we arrived were incredible. They had very little support. First they had to clear the area and everything else. On their side, in the first day of the investigation, there were three broken legs, eight snake bites from poisonous

snakes and one cardiac arrest. It was severe conditions.

(At the site) This is the centre section of the wing. The main landing gear is right there below you – one of the pieces; the other piece is just down the hill.

GREG PHILLIPS *(Systems Specialist, National Transportation Safety Board)*

As we surveyed the site, we decided to set off in the direction of where the local Indians had been doing some searching and had reported they had seen some other parts of wreckage. As we walked into the area, we found the first body. I was with a Panamanian official – Cal Walbert from the FAA.

One of the first things that we noticed about the body was that it was unclothed. We then found two or three other bodies in the immediate area and they were all unclothed also. We had heard discussions, and in our training over the years, we knew that the lack of clothes generally indicates that the people came out of the aeroplane at high speed and the clothes were ripped off through high-speed break-up.

When I first came to this job I had some concerns about what it would be like approaching an accident scene with death and dismemberment. I found it disturbing in a way that it didn't keep you from doing your job. I think, you see, that the chance that you could do something to keep it from happening again helps you.

NARRATOR

The searchers found 47 bodies. All the crash victims were accounted for. These bodies have already furnished a first clue to the crash: the aircraft broke up at high speed. They will now be minutely examined for traces that might point to fire or to the explosion of a bomb.

CALVIN WALBERT *(Explosives expert, Federal Aviation Administration)*

If in fact you had a bomb in the cargo area, depending on its size, you could very easily get some components of the bomb such as clock parts, battery parts, parts of the container – let's say it was inside a radio, you may get parts of that radio that would penetrate the floor and the passengers sitting directly over the top of it, might in fact become embedded in their feet and

their legs, if they had their legs spread out. If the device was underneath the seat itself it could be in the buttocks area. If a flight attendant was walking by with a drink-cart or service-cart they could have it in their extremities. If it was up in the overhead, you would get it up in the upper torso and the head area. And that's why we go to the medical examiner and we ask that they do a full body X-ray.

NARRATOR

A few days later, in their Washington labs, the NTSB examine the cockpit voice recorder. If there had been a bomb, the sound might appear on the tape.

THOMAS HAUETER

This particular recorder is a coaxial recorder, which has two types of reel, one on top of the other.

NARRATOR

The results of the examination are very disappointing.

THOMAS HAUETER

The last recording on the tape was a flight that occurred about seven to eight days prior to the accident flight. The tape had broken and quit running seven or eight days before, so we didn't have the voice recorder for the accident flight. We had the recorder looked at, inspected – it was in fairly good condition . . .

NARRATOR

But when they opened up the box they found a bird's nest of tape tangled in the top of the recorder.

THOMAS HAUETER

Possibly during the last maintenance a couple of screws were left out, or a couple of washers were left out on rebuild. It allowed the tension level to get too high on the tape, and broke the tape.

NARRATOR

The team check with the airport control tower. They're looking for any recording of sound from flight 201.

CALVIN WALBERT

Is there a tape-recording from the night of the accident?

AIR TRAFFIC CONTROLLER

We lost power.

CALVIN WALBERT

We're trying to determine which pilot was talking on the radio, because normally the pilot talking on the radio is not the pilot flying the aircraft. We're trying to figure out which pilot was flying the aircraft.

THOMAS HAUETER

The interest here was that the captain of the flight was one of the highest-time pilots, in fact was *the* highest-time pilot – he had number one seniority in the airline. The co-pilot or first officer was one of the most junior pilots with the airline, and so we would have liked to have known who was flying the aeroplane.

NARRATOR

As the days passed, the Indian and Panamanian searchers were finding more pieces of the aircraft. The location of each was noted, then it was brought to a collection point, identified and catalogued.

DIALOGUE BETWEEN SEARCHERS

'... and there's some real sooting on one section of it, and I went a little further to the right and I've got a microwave oven from the galley, it looks like...' '... probably number one engine...' 'Is this the engine that he was taking us to?' 'No. This is the other one.' 'This is the other one.' 'This is number two.'

NARRATOR

In Panama City the investigators were looking for any sign of faults or failures that might have caused the crash or been caused by it.

The team was puzzled by the fact that they were still missing large parts of the aircraft, and by the pattern of the wreckage. Reporting to Zosimo Guardia Tom Haueter admits his bewilderment.

THOMAS HAUETER

We're finding pieces from the front of the aeroplane with pieces from the rear of the aeroplane, and vice versa. We're finding right-side pieces on the left side. If you take a look at the wreckage diagram, there's no pattern to how things came down. It's all over the place and that is really confusing. The accident I had before this was complicated, but we had the whole aeroplane. It was burned but it was all in one spot, and it was just a matter of trying to go through and understand what happened. It took time to prove that by simulations and by tests, but at least we had the whole aeroplane.

GREG PHILLIPS

This [central section] is a very heavy section of the aeroplane. It has the landing gear, it has the centre wing structure, which is very heavy. This other piece that broke off should be lighter, depending on the size. It could have gone on beyond it.

BOEING ENGINEER

There is an area here with big, broken trees, but no parts found. There's a deep valley and something is in there, but nobody found any parts. But we know something is in there.

GREG PHILLIPS

But people who've been there haven't seen anything, so we'd like to go back to that area. That may be a substantial part of the aeroplane we haven't seen.

10 **NARRATOR**

They found the cockpit, and another mystery. The only sign of the captain was his unbuckled seat-belt. At the bottom of the wreckage they could see the body of the co-pilot.

TOM HAUETER

I can see an arm over here. There's the captain's seat? See, there's the captain's floor track, this is the captain's seat. How did he get out? He should be lying on top of the co-pilot...

(Interview) Subsequently, when the cockpit was cut open, he was found beside the first officer, but it did raise the question as to – you know, it's very unusual for pilots not to have their seat-belt on.

NARRATOR

The co-pilot's father places a memorial to his son.

The first funeral is held. Families in the close-knit airline community mourn one of the five flight attendants.

This is Panama's first major plane crash in 40 years.

In the jungle, the investigators are finding more burnt wreckage.

CALVIN WALBERT

Boy, missed that one. It's got a number on it so why don't we get the number...

NARRATOR

They're beginning to think that the plane was on fire before it crashed. Aircraft remains that show traces of fire on the inside point in this direction.

CALVIN WALBERT

(On walkie-talkie) This is Cal again. We're back up in the area that I was in that first day, and we're finding pieces of obvious burnt aircraft. We found that three-section of seats again, and now we've got a window-belt area that's really sooted. Three windows are missing, one that's intact is sooted, and the frame members are all sooted up inside.

The forward cargo door butts in right on that edge there. It's upside-down.

THOMAS HAUETER

So we're seeing sooting forward of this cargo area. There's the liner.

CALVIN WALBERT

Look at this bubbling here.

THOMAS HAUETER

Everything we've seen so far has been sooting. This is a clear evidence of a major fire.

NARRATOR

The parts leave by helicopter for a ten-minute journey to the village of Sambu. Most of the wreckage has been found and carried in by Kuni Indians who are paid cash for each item. The Kuni have walked in for miles to join the salvage operation, and the local village economy is given an inflationary burst from their earnings.

To be closer to the crash site, the investigating team have set up a forward base in Sambu. Communication specialists from the United States have set up a satellite link with Washington. The investigators tell their head office about their growing conviction that there was a fire on board.

THOMAS HAUETER

(Speaking into radio) The biggest thing we've found is a section of overhead storage bin honeycomb material that's completely burned. It's been through one hell of a fire, but there's no fire around it. We feel pretty convinced that that thing was on fire prior to the break-up. It was found a long way away from the burn area.

NARRATOR

In Panama City the pieces of wreckage that show evidence of burning are minutely examined.

FAA ENGINEER

After that part was broken out the aeroplane it could have been flying through the air and punched the tree . . .

THOMAS HAUETER

What we were trying to find out was whether this piece burned up in the aeroplane while it was intact, or whether it burned during the break-up or after the break-up.

NARRATOR

Evidence for or against a fire is most likely to come from an examination of the victims. A team of American pathologists arrives to help the Panamanians, who don't have enough specialists to cope quickly with so many bodies.

PATHOLOGIST

The individuals here start collecting the records by calling up the parents and the family members of their next-of-kin, they tell us who their dentist was, the dentists forwards or faxes their records to us and then – you see, we don't know who these people are.

NARRATOR

After 47 autopsies the pathologists deliver their report.

PATHOLOGIST

One of the questions that we were asked is: was there a fire aboard? Based on the examination of the remains that we have made, and that the Panamanian authorities had made prior to our arrival, there's no indication of any fire in the passenger compartment. This is based on the fact that we have no evidence of burning or singeing of skin, and there's no evidence of soot or smoke inhalation in tracheas, and all of the tracheas on all 47 people who were examined were opened and were examined just for that.

SECOND PATHOLOGIST

In both the pilot and the co-pilot no soot was found in the airway, there

were no shrapnel injuries and there were no thermal injuries or burns evident upon either body.

NARRATOR

No fire before the crash, no explosion. For the investigators it's back to square one, a dead end. But that's common in crash investigations.

THOMAS HAUETER

As crude as it may sound, in an investigation we take at the outset a shotgun approach, that everything's suspect, and so we go down every alley, and of course many are going to turn out to be blind. We expect it, that sometimes it's going to be embarrassing – you put an awful lot of effort into something that turns out to be nothing. And after going through all of that, it came down to: no, there wasn't smoke or fire inside, and we had to start looking for other sources of the accident.

NARRATOR

The turning point in the investigation comes when the tape from the second black box, the flight data recorder, is analysed in Washington. It provides a second-by-second account of the readings on the pilot's instrument panel. This is now the only testimony to what happened in the cockpit minutes before the crash. This recorder worked perfectly, but as the data scrolls onto the screen, it paints a picture of an aircraft behaving in a way which mystifies the investigating team in Panama.

THOMAS HAUETER

(Speaking into radio) Can they fax us a copy of that data tomorrow?

NARRATOR

The data from the flight recorder doesn't correspond to anything they've seen before. That night they discuss it in their hotel room.

FAA INVESTIGATOR

He's holding that for 20 seconds – that's a pretty good time. He then makes a left turn, 35 degrees bank to 130. That's excessive. A second and a half

later he's in a 112-degree right wing bank. So he's over the top.

THOMAS HAUETER

But look how fast he does this. He goes from three degrees right roll . . .

BOEING ENGINEER

And in how much time is that? Five seconds?

THOMAS HAUETER

No, that is in one second.

We've got to work through this data completely – we don't know. What my engineers are telling me is that what we see is what's there . . . But this gets better. You go on down through the data and it's pretty constant. But now look at this. You get down here and suddenly it goes from left wing down 36 degrees to right wing down 25 degrees, once again in one second.

BOEING ENGINEER

One second, then what?

THOMAS HAUETER

Then the second later it's 115 degrees. So there's a lot of this data that you take a look at and it doesn't make any sense.

NARRATOR

To try and visualise what the readings mean, the NTSB make a computer animation from the output of the flight data recorder. It picks up Copa 201 after it's made a detour round the storm just before it turns back onto course. The vertical bars indicate five-second intervals along the aircraft's path.

THOMAS HAUETER

Now he starts to turn to the right to get back onto his original course. By the G-trace you can tell he's in smooth air, he's out of the storm and probably at this point he's told the passengers they can take off their seatbelts and walk freely round the cabin. Now the aeroplane starts to level off,

but it doesn't quite level. There is still a 4-degree right bank in it. It's going straight but it has this 4-degree right bank, so it's not flying in the smooth, normal pattern. This is very difficult for the aeroplane to do. Now you see it all of a sudden snaps to the left, left wing down about 35 degrees. And once again the heading doesn't change very much, but the aeroplane is flying with this severe bank and it is, I believe, beyond the authority of the rudder to fly with this much bank in the aeroplane. And it continues like this for quite some time, when suddenly it snaps to the right. And once again the rate of the snap is beyond the rate that a 737 can do. You're talking aerobatic aeroplane here, not just basic bus-transport-type. Once the nose is down, it's inverted and air speed builds rapidly past 480 knots, the altitude is dropping off rapidly and we lost the recorder below 10,000 feet, by which time the aeroplane broke up due to aerodynamic forces.

We took the data from the flight data recorder, we loaded it into the Boeing simulator and asked various pilots to try to fly the data.

NARRATOR

The pilots were presented with exactly the same instrument readings as the Copa pilots.

THOMAS HAUETER

We use the data to try to understand what the pilots did, what they could have done, how the switches are set, what data is being presented to them by the instrumentation. It's a very important investigative tool.

NARRATOR

Out of 50 simulated flights, reacting to the same data as was seen by the Copa pilots, 49 times the pilots crashed the aeroplane.

In Panama, the focus of the investigation has shifted to a possible fault in the instruments. The team return to the remains of the cockpit. If the data from the flight recorder shows the aircraft doing impossible aerobatics, then maybe it never performed those manoeuvres. Maybe it was the readings from the instruments that were faulty, leading the pilots to crash the aircraft. There are mysteries here, too.

THOMAS HAUETER

That's interesting. Cabin altitude is reading 25,000. Something opened up.

PANAMANIAN INVESTIGATOR

Well, how odd. If he was descending it should move also.

THOMAS HAUETER

Sure it should move.

PANAMANIAN INVESTIGATOR

But why did it stay on 25,000?

THOMAS HAUETER

If you lose electrical power? It's electrically driven.

CALVIN WALBERT

Well, but so is this instrument.

THOMAS HAUETER

Yeah. *(Shakes his head)*

NARRATOR

Suspicion focuses on the instrument that tells the pilot at what angle the aircraft is flying – the 'artificial horizon' or ADI. On a dark night it's the only way to tell if the aircraft is level, and the apparently violent manoeuvres of Copa 201 seem to have been in response to the ADI. Its failure rate is designed to be one in a billion. Most pilots trust their ADI.

737 INSTRUCTOR PILOT

(Demonstrating in cockpit) This is a control for a system that can tell what is level in relation to the earth. It can also tell if the aeroplane is level with that, or if it has one wing up, one wing down, if the nose is above the horizon or below the horizon, and it will display this information on this instrument. The blue part represents the sky, above the horizon, and the dark part represents the earth, below the horizon. This one does the same thing and

displays that same information on this indicator on the other side of the cockpit. Normally the left-hand side control displays information on the left-hand indicator, the right-hand control on the right-hand indicator, so long as this switch is in the central position. If one of these systems should fail, then we can use this switch to put both displays on the good instrument, like so. If both of these systems are operating normally, that switch should remain in the centre position and you have two independent systems, one backing up the other for safety.

NARRATOR

If both the main instruments were to fail, there is a third, smaller, independent ADI on the panel in-between the pilots, slightly off their line of sight. And the team find that the pilots have selected both ADIs on one gyroscope. This is an important discovery. By examining the electrical relays that were commanded by the selector switch, they confirm that when the aircraft power was on, the switch was indeed selecting one gyro for both instruments. They're satisfied that it was not moved on impact or in the dismantling of the cockpit. So at the time of the crash the pilots had lost a valuable element of safety.

Was this deliberate on their part, because one of the indicators had gone wrong, or had they made a mistake? And in any case, what about the third, independent instrument?

All the instruments were gathered and investigated. Every one of them had a service record. The aircraft had originally been operated by a British airline and so this phase of the investigation took Greg Phillips far from Panama.

GREG PHILLIPS

We decided, after looking at the records that were available in Panama City, to go to Luton and take a look through the records of the aeroplane since it was delivered from Boeing. We followed the history of all the cockpit instruments that we were concerned with from the day they crashed to the day that they were born at Boeing, that they were first delivered. The aeroplane, I believe, was initially delivered in 1980 from Boeing to Britannia, so it had had several changes. When an instrument was removed

from the aeroplane we looked at the records to see why it was removed. We followed the instruments to the records of repair shops around the UK to see what had been done to repair them. We were looking for a trail of problems with the aeroplane or with instruments in that part of the aeroplane systems.

NARRATOR

After exhaustive checks, they found nothing wrong in the history of Copa 201's instruments. But the investigators still believed that an instrument error was at the root of the airliner's fatal aerobatics. They made a new simulation. Here the grey image does what the instruments were telling the pilots. The stick image shows what the team think the aircraft was really doing.

THOMAS HAUETER

He'd been deviating round a thunderstorm and now has to make a turn to get back onto course. It's a gradual turn; the rates suggest it was done by autopilot. Now the aircraft will start to roll out on course and you'll notice that the grey aeroplane will hold a 4-degree bank, while the stick-figure aeroplane starts rolling to the left.

NARRATOR

As the grey plane, according to the false readings, freezes in a 4-degree right bank, the real plane rolls left. Suddenly, the grey plane snaps round to match reality. Whatever fault was affecting the instruments has gone away and the pilots realise their true position. They desperately try to level the aircraft by rolling to the right, but the instrument has frozen again and while the real aircraft rolls almost upside down, the pilots imagine they're still in a left bank. Once again the instrument unfreezes and the grey plane snaps round to the right. The pilots are completely caught by surprise. This is when they lose control of the aeroplane.

THOMAS HAUETER

(Reading from simulated instruments) Over 400 knots, 17,000 feet, 450 knots, 14,000 feet, almost 480 knots until the data ends at less than 10,000 feet.

NARRATOR

Tom Haueter and Greg Phillips have come to present their theory to the Panamanian chief investigator and the Panamanian team. Once again they go over the last 70 seconds of the flight.

THOMAS HAUETER

... here are timing bars, they're just five seconds apart. He's levelling out, but he doesn't quite level. He's got a 4-degree bank. The attitude indicator is stuck at 4 degrees. That's what he's seeing. Suddenly it snaps, goes the other way, sticks again. Now it's stuck at 35 degrees. He's bringing it back. He's got a little bump on vertical G but not much. He's still trying to roll the aeroplane. There. Now he's in trouble.

(Interview) What you would feel if you were in the cockpit of the aircraft or in the passenger compartment was nothing. It was always 1G pushing you in the seat, it was a very smooth, comfortable manoeuvre – up until the time the aircraft was actually almost inverted. They didn't realise they were in trouble until there was no recovery possible.

GREG PHILLIPS

The first indication we had that something didn't make sense to us was that the data showed that the aeroplane made several rolls and would stop when it had made the roll, the roll would just freeze, and normally aeroplanes don't do that, they continue moving from one place to another. Looking at this data a little more closely, we started to look for possible explanations of what caused the data to look like that. Did the aeroplane really do that? We didn't think so. Was something failing, and what was it?

NARRATOR

What makes the theory hard to swallow for the Panamanians is that in all of the tests of the instruments the team have found no faults whatsoever.

GREG PHILLIPS

Our primary concern initially was to test the attitude indicators – the captain's and the co-pilot's. We tested those at Collins in Cedar Rapids. We found no failures. The attitude indicators for both sides worked. We turned

20 them, we banked them, we pitched them, we rolled them, we put them in a hot chamber to heat them up to see if they would fail. We did several tests and they worked – after the crash they worked just fine. That’s when the discussions started about what could happen, what would cause this trace to stick this way.

The only part of the system that we haven’t looked at is the wiring between the components, between the gyro provides raw information what the pilot sees. We intend to begin this afternoon and, over the next couple of days, to examine that wiring and look for any possibilities that there was some failure of that wire.

ZOSIMO GUARDIA

If you don’t get some kind of proof with the cables regarding that point – this is a *theory*...

THOMAS HAUETER

At the Safety Board we determine probable cause, and I would say that we have eliminated every other possibility that could bring this aeroplane down. There’s no indication of bombs, terrorism, weather, control surface, engines. We go through the process of elimination and of everything we’ve seen of the wreckage, of the instrumentation and of the data, this is the only piece that doesn’t make sense.

Now Greg’s absolutely right. We can look at this whole wire bundle and we may find nothing wrong with it. But *something* caused this instrument to read this way.

NARRATOR

One more trip to the jungle. The investigators are sure that their theory is the only one that explains the crash, but they must now test the wiring in the aircraft to see if they can find the fault.

GREG PHILLIPS

Want to go back to 22? 22, good. 21. I’m going to go down a little bit.

BOEING ENGINEER

Go down to 17.

GREG PHILLIPS

OK, here’s 20, 19, 18, 17, 16, 15, 14, 13, then back to 22

NARRATOR

Several things could go wrong with the wires. They could short-circuit, break apart, or come loose from their connectors. But the ‘on again/off again’ effect in the instrument data looks as if it was caused by an intermittent, occasional fault. These are the hardest faults of all to find, especially in the miles of wiring in the airliner. It’s a grinding, painstaking process. And then a Panamanian engineer reports that he has found a loose wire

DIALOGUE BETWEEN INVESTIGATORS

‘This one just came out easily? No pull?’ ‘It wasn’t pulled, it just fell out.’ ‘What was its condition before it just fell out – was it hanging on by a string, or . . .’ ‘Well, what we can get into that, we’ll look at that . . .’

THOMAS HAUETER

(On telephone) We have the whole wire bundle from the aeroplane here and they were pulling each of the wires out of the connector and this one wire just fell out.

NARRATOR

It looks as if the loose wire is the one that connects the gyroscope to the ADI. Confirmation about the specific role of this wire has to come from the Collins Instrument Company in America.

BOEING ENGINEER

(On telephone) We need to get hold of Collins pretty quick, we’re trying to get hold of Collins right now, so I think I better get off the phone . . .

ERNESTO PONCE

(Talking to Collins on another line) He's on vacation? Just a minute. He's on vacation.

BOEING ENGINEER

Just a moment please. Oh, shoot.

ERNESTO PONCE

Talk to this guy and find out when we'll be able to . . .

THOMAS HAUETER

(On another line) No, the pin and the wire are no longer attached to each other. That's the problem.

NARRATOR

If this is the right wire, then the last piece of the puzzle is in place. Boeing will have to notify maintenance engineers round the world to check this wire in thousands of Boeing 737s.

BOEING ENGINEER

(Talking to Collins on the telephone) One of the wires came loose and fell out, apparently, and we wanted to find out what impact it would have on the ADI indication if that wire happened to, say, disconnect . . .

I just wanted to confirm that if the error signal was lost, then the instrument amplifier would register zero error coming from the ADI and thus the roll indication would freeze. Is that right? 'That's right.' OK.

THOMAS HAUETER

And would you get a flag?

BOEING ENGINEER

No, you wouldn't get a flag in this case – as there is no error signal, no flag.

NARRATOR

As it's prepared for sending to the lab, Greg Phillips has second thoughts about the correct identity of the wire. The team use videotape shot by our cameraman to double-check.

GREG PHILLIPS

We called it 43, but it wasn't 43.

US INVESTIGATOR

Where's 42?

GREG PHILLIPS

Forty-two is the second open hole right up here.

US INVESTIGATOR

They're both empty.

GREG PHILLIPS

Yeah. Why did I say it had a wire in it?

US INVESTIGATOR

We just were so anxious to find the 42 wire broken, and the 43 wire, we just called it that – it just came out of our heads.

GREG PHILLIPS

I honestly wouldn't go to the trouble to check those other aeroplanes.

THOMAS HAUETER

Through all of our search in the jungle, through all the wiring traces and everything else, we never found where the intermittent failure was. We looked everywhere. We took apart the whole front end of the aeroplane. The data recorder shows it was there. The way the aeroplane was wired we knew that was what the pilot saw. But we never actually found what caused that signal failure.

NARRATOR

They didn't have the final proof. So they went back and tested the instruments at the manufacturers and simulated the disconnection of the wire from the gyroscope and then its re-connection. This reproduced exactly the freezing and the apparent wild manoeuvres that they observed from the data in the Copa crash. This confirms their probable cause.

THOMAS HAUETER

Looking at the data, looking at the way the aircraft behaved, we can come up with a scenario that fits. Why? We can see how the pilots could have been led to believe that they were doing the right thing when in fact they weren't. We can document how that type of failure can exist and what would have happened.

We cannot allow a plane to crash and not find out why, because if one happens tomorrow we'd be liable, if nothing else, for not being able to tell the world: yes, we know what happened here, there are corrective actions that can be made and this is what needs to be done.

NARRATOR

That has taken more than 18 months' work by investigators. Spread between government agencies, airlines and manufacturers, it has cost more than a million dollars.

The Panamanians are about to publish their final report. It will be read and acted on around the world. As well as the engineering questions, it will have to address the crew's training. Why did they continue to trust their main instruments once they'd switched both to one gyroscope, and why weren't they more aware of their stand-by instrument? These human questions are, as so often, at the heart of the accident.

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London W3 6XJ

OTHER TRANSCRIPTS AVAILABLE FROM THIS SEASON OF *HORIZON**Small Arms, Soft Targets*

Modern armies demand the most effective weapons: rifles with more firepower, fragmentation weapons to injure as many as possible, landmines to scatter from the air, lasers to blind the enemy. Now there is an international campaign to frame laws of war limiting the design and use of weapons aimed at 'soft targets'.

The Last Mammoth

The mighty mammoth so nearly made it into the modern world. Evidence produced last year by Russian scientists, after fossil finds in the remote Siberian Arctic, indicates that mammoths – or at least the pygmy mammoth – were still living as recently as 500 years ago, while most prehistoric species perished at the end of the last Ice Age.

This film follows the world's mammoth hunters as they try to establish the reasons why the animal, an ancient relative of the elephant, finally became extinct. Did human hunters or a climate change drive them to Siberia? The programme ends on the island of Wrangel, cut off from Siberia when the sea level rose. It was here, protected from human hunters, that the mammoth last walked.

Genie

In Los Angeles in 1970, a 13-year-old girl was found who had lived as a prisoner since birth, tied to a potty in a back room of her parents' house, unable to move anything except her hands and feet and without having heard human speech.

After her escape with her blind mother, Genie (not her real name) became an object of fascination to psychological and linguistic researchers because she couldn't speak and was completely unsocialised. For a while she was fostered by the head of the project's family, but when scientists ceased to be interested in her she was returned, still severely disturbed, to her inadequate mother and forgotten.

Horizon tells her story and investigates what subsequently became of the girl after she helped scientists with their study.

Deathwish – the Untold Story

Twenty years ago, two Scottish pathologists, Professor Andrew Wyllie and Sir Alastair Currie, came across cases of people whose skin cancer had cured itself. Later, they found patients who had made near-miraculous recoveries from what should have been terminal cancer. The patients had somehow reversed itself, healing naturally.

These chance cases led Wyllie and Currie to speculate on 'programmed cell death', in which they suggest that the recoveries were the result of sick cells killing themselves, the implications of which could revolutionise cancer treatment.

Hubble Vision

The less-than-perfect pictures received from the Hubble space telescope, following earlier delays in the project, were a scientific disappointment and a financial embarrassment.

Much was at stake, then, when a rescue mission flew into space to chase, catch and repair the equipment. The precision needed is indicated by one of the astronauts when describing the main mirror of the telescope: 'If you scaled up the mirror to the size of the 48 continuous states of the USA, it would be smooth to one inch.'

The mission proves almost as smooth, in spite of the constant need to react to the unexpected, and the relief of those on the ground is obvious.

Horizon follows this journey into space from training to triumph.

Transcripts are £2, including postage and packing.

Cheques or postal orders (made payable to BSS) should be sent to:

Horizon (title of programme), PO Box 7, London W3 6XJ

HORIZON 'SPECIALS' (*transcripts with extra information and illustrations*)

The Man Who Made Up His Mind

It has long been accepted that the brain is an information-processing machine, storing and evaluating, though the relationship between this neural computer and what we understand as 'the mind' is less clear. But now Gerald Edelman believes he has made the connection, and in doing so has challenged the existing view of the brain itself.

'It is the first radically biological theory of the mind,' says neurologist and writer Oliver Sachs. Edelman pictures the brain not as a computer but as an evolving ecosystem of competing groups of cells. In his 'neural Darwinism', just as natural selection hones a species to fit its habitat, so 'neural selection' helps gear the brain to its environment. This film explores the implications of Edelman's radical theories.

'Specials' are £3, including postage and packing.

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BBC**BSS**

Horizon celebrates 30 years of science documentaries in 1994. The BBC's longest-running science series continues to reflect the forefront of developments in science, medicine and technology. Each programme is the result of several months of research and brings together the opinions and knowledge of experts in each field.

In 1994 Horizon transmits on BBC2 on Mondays at 8.00 pm and is repeated on Saturdays at 2.10 pm, from January through to May, returning in late October.

HORIZON



Air Crash – The Deadly Puzzle

Text adapted from the programme transmitted

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